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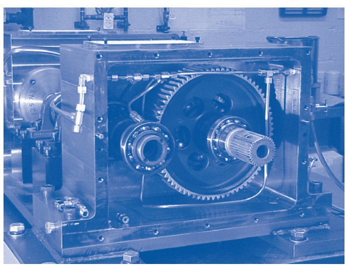
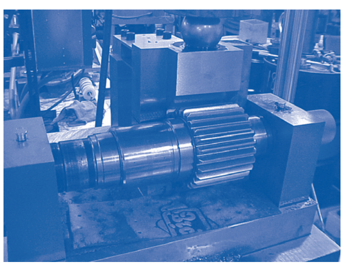
QUARTERLY 2007 No.1

Gear Repair Project by Super Finishing Process Nearing Completion





iMAST recently completed an end-of-project meeting to present the final results of its Navy ManTech gear super finishing program effort. Attending the meeting were representatives from NAVAIR, Boeing, and the U.S. Army.

Large quantities of aircraft gears are currently scrapped at Navy Fleet Readiness Centers (formerly Naval Aviation Depots) in the routine process of helicopter transmission overhaul. Annual acquisition costs for replacement of these gears at Fleet Readiness Center (FRC) East at Cherry Point, North Carolina (for the CH-46 Sea Knight alone) is estimated to be over $3 million dollars. This project was initiated to demonstrate that a large portion of these "scrap" gears can be repaired and recycled back into their respective aircraft, resulting in a significant cost avoidance.

The repair process identified by iMAST was the Isotropic Super Finishing (ISF) Process developed by REM Chemicals, Inc. of Brenham, Texas. This process has been found to be capable of uniformly removing very thin layers (0.0001 to 0.0002 inch.) of material from the tooth surfaces of hardened aircraft gears.

During the fleet overhaul process, it is policy to scrap transmission gears that have minor FOD or micro-pitting surface damage due to corrosion and fatigue. Removal of the surface damage on these gears, however, using the ISF process, has shown that the number of actual gears being scrapped can be significantly reduced. Process results identified by iMAST have proven a large number of these gears can be returned to service within Original Equipment Manufacturer (OEM) gear tooth geometry, dimension and metallurgical specifications.

A preliminary analysis of scrapped CH-46 "Mix box" gears received from FRC Cherry Point suggested that over 50% of the gears could be salvaged using the ISF process. The preliminary analysis also established a five-year (present value) Return on Investment (ROI) of 5.9, based on repairing only 4 out of the 20 gears in the fore and aft transmissions of the CH-46 Sea Knight. In order to establish the feasibility of this repair process, scrap gears repaired by the ISF process were scientifically evaluated for gear strength and durability. The performance of these gears, as compared to the strength and durability of new gears procured from the approved Navy vendor, was shown to be very promising.

Test rigs and fixtures at iMAST/ARL Penn State were specifically designed and built to accommodate the spur pinion and the collector gears pair of the CH-46 Mix gear box. New spur pinions and collector gears were acquired

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Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE **2007**	2. REPORT TYPE	3. DATES COVERED **00-00-2007 to 00-00-2007**

4. TITLE AND SUBTITLE **iMAST Quarterly, 2007 Number 1**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Penn State University,Applied Research Laboratory,Institute for Manufacturing and Sustainment Technologies,State College,PA,16804**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**8**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

PENNSTATE

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DIRECTOR'S CORNER

My Welcome Aboard

Just before Thanksgiving my boss came into my office, with his hand extended, to offer me the iMAST directorship and say congratulations, in the same breath. He assumed I wouldn't hesitate and he was right. I am proud to officially be a part of the ONR Navy ManTech team. Since retiring from the Air Force, continuing a life of service to our nation and the DoD has been my primary ambition. ARL Penn State and iMAST provide me an opportunity to continue making a difference.

Now, what can you expect of the new director? I've spent the last three months, as the interim director, with a constant sense of awe as I've observed the ManTech program office operate. The contributions of the various centers of excellence and our own staff here at iMAST make me proud. The impact is inspiring, albeit a little intimidating from my initial perspective. This group has a sense of patriotic fervor that is centered on supporting the Sailor and Marine. I hope to help. I also plan to work hard over the next six months in three primary areas:

1. Meeting and getting to know the players, programs and infrastructure is my top priority. I hope to make up for what my fellow (prior DoN) co-workers call "shortcomings" by visiting as many shipyards, Navy and Marine Corps depots, appropriate OEM facilities, Navy Labs, and program management offices as is humanly possible.

2. I will be looking internally at our business practices with the intent to improve our efficiency and put more funding on the line for hands-on work.

3. I hope to significantly increase the amount of collaborative effort we support with the other Navy ManTech centers of excellence, government depots, Navy labs, and contractors. ARL, as the host of iMAST, has expertise in many different technologies that can be used synergistically with other centers to improve mission capability and support.

The neatest thing about this new job is iMAST's dual impact mission. Navy ManTech projects are, by definition, affordability- centered. iMAST is dedicating dozens of man-years effort to help the Navy acquire more ships -- faster, better and cheaper. The impact of our contribution will be felt by Sailors 50 years from now. RepTech projects typically impact the logistics and maintenance personnel, military and civilian at all three levels, in the near term. The projects that iMAST supports make our Sailor's and Marine's lives a little easier today by improving the operational availability of their weapons systems in support of our national security priorities.

As always, if you have ideas that can better help us accomplish our mission, please don't hesitate to give us a call. We are proud to serve our men and women in uniform.

Tim Bair

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Focus on Materials Processing

Progress in High-Velocity Particle Consolidation Technology

by Timothy J. Eden, Ph.D.

The Materials Processing Division of the Applied Research Laboratory has been conducting research and transitioning technology for the past decade. A brief review of the High Velocity Particle Consolidation Process (HVPC) along with progress and current efforts will be presented in this article.

High-Velocity Particle Consolidation (HVPC) is the process of applying metal and composite (metal/ceramic) powders on to a substrate by accelerating to velocities ranging from 400 to 1000 m/s. Upon impact the metal particles deform and bond with the substrate. Particles continue to impact the surface bonding with the already deposited particles building up very dense coatings. The deposition rate for the HVPC process can be as much as 15 kg/hr or higher. The technology was developed in the middle 1980s at the Institute of Theoretical and Applied Mechanics of the Siberian Division of the Russian Academy of Science in Novosibirsk [1]. The technology was later patented in the United States in 1994[2]. The HVPC is widely used in Europe and is gaining acceptance in the United States[3]. The process is also known as Cold Spray, Cold Gas Dynamic Spraying, Kinetic Metallization and Supersonic Particle Deposition.

The basic HVPC process is shown in Figure 1. In the HVPC process, a compressed gas, usually nitrogen, helium or air is expanded through a converging/diverging or DeLaval nozzle to supersonic speeds[4,5]. Powder is introduced into the gas stream slightly upstream

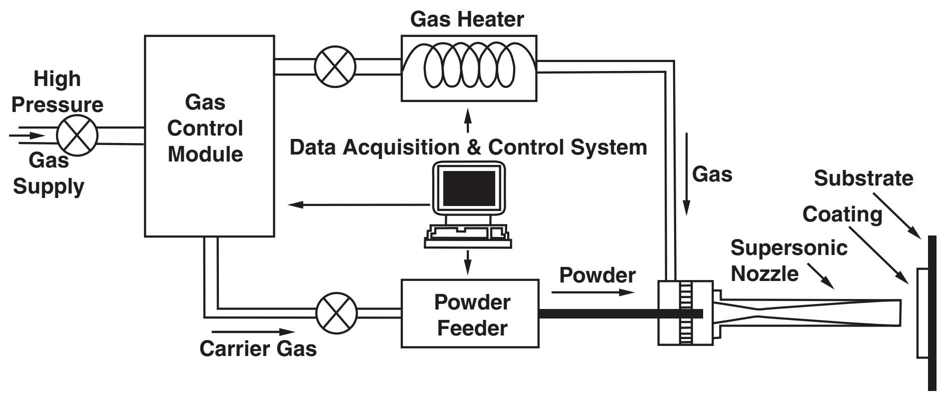

Figure 1. Schematic of the High Velocity Particle Consolidation Process. The process is robot controlled.

of the converging section of the nozzle. The expanding gas rapidly accelerates the particles to velocity sufficient to build up a coating. A gas heater is used to increase the gas temperature which results in higher gas velocities. This also increases the particle velocity and temperature to improve the deposition characteristics of the powder [6]. The particle temperature remains well below melting temperature of the particle. The substrate temperature remains below 150°C greatly reducing or eliminating any adverse thermal affects. There is no increase in the oxide content in the coating and in some instances the oxide level in the coating is less that the oxide content of the starting powder[7]. These characteristics make HVPC an ideal coating process for select applications such as the application of corrosion and wear resistant coatings.

Advances in nozzle design, process optimization and powder processing have lead to the ability to deposit very dense coatings using the HVPC process. Aluminum, aluminum alloys, copper, stainless steel and nickel have all been deposited with densities greater that 99%. The HVPC process also produces excellent material interaction at the coating/substrate interface. An example of the unique microstructure and coating/substrate interface that can be produced by

PROFILE

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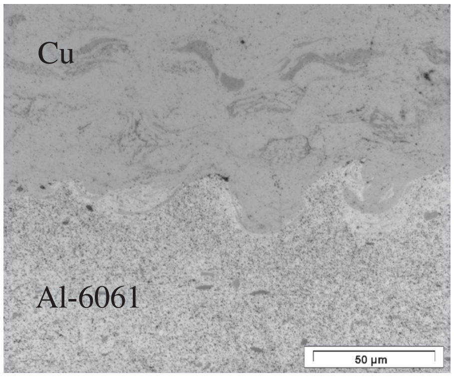

Figure 2. Micrograph of Copper powder deposited on Al-6061. The mixing of the materials at the interface is clearly visible.[7]

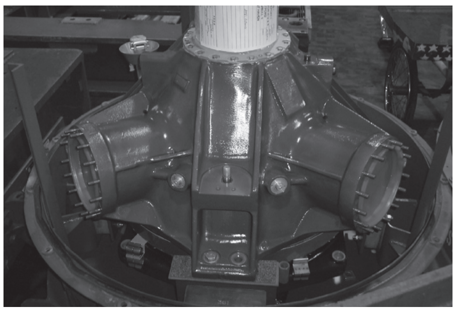

Figure 3. SH-60 Helicopter Transmission Gearbox

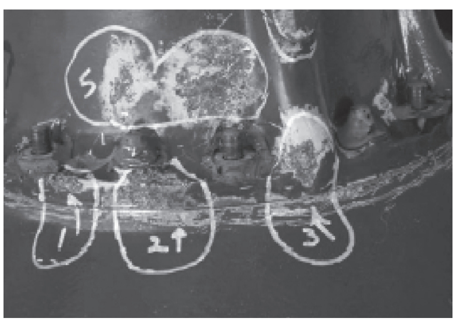

Figure 4. Corrosion on Gearbox

HVPC process is shown in Figure 2[7]. The substrate is Al-6061 and the coating is copper powder. The coating is 99.9% dense. As a result of the process, the high velocity particles are subject to severe amounts of plastic deformation. This plastic deformation can also occur in the substrate as well. The result is a coating/substrate interface where there is mechanical mixing of the material that is free of voids and inclusions. The extent of the interfacial mixing is dependent on the coating/substrate material system.

Improvements in nozzle design have lead to higher deposition velocities and the ability to deposit larger particles. Gas dynamic models were used to design nozzles that can substantially increase particle velocities[8,9]. Increasing particle velocity results in denser coatings and higher deposition efficiency. Increasing the length of the nozzle from 83mm to 211mm, with nitrogen as the carrier gas, the calculated velocity of a 12µm copper particle can be increased from 553m/s to 742m/s. This is a 33% increase in particle velocity. The increased velocity leads to an increase in the deposition efficiency from less than 10% to close to 80%. There are fabrication and material constraints that limit the practical length of the HVPC nozzles. Other nozzle improvements include the use of new materials to improve powder flow through the nozzle and design optimization to minimize the gas flow through the nozzle.

One of the frequently asked questions is how does the cost of applying coatings with the HVPC process compare to the cost of applying coatings using other thermal spray processes. To address this issue, the software package Cost Analysis Software (CAS) was developed to accurately calculate the cost of applying a coating using the HVPC process[10]. Code inputs include the cost of the powder, gas, and electricity, nozzle dimensions, carrier gas, powder mass flowrate, substrate dimensions, deposition efficiency, desired coating thickness, start up and shut down times, and if desired, labor, burden and equipment amortization. The output includes cost by category (gas, powder, labor, burden, amortization), cost per unit area, spray time, and the number of passes required to achieve the specified coating thickness. The CAS can also be used to determine deposition efficiency given the process parameters. The CAS was calibrated through experimentation and on the Navy Mantech Project C0934 AAV Enhanced Appliqué Armor Kit (EEAK) Product Improvement[11]. It was demonstrated during this program that the HVPC process was cost competitive with wire-arc spray for the deposition of aluminum on steel. Future plans for the CAS include developing modules for complex geometries and to predict the cost of other thermal spray processes.

The current ManTech program involves the development of corrosion resistant coatings for the magnesium gearboxes on the SH-60 Helicopters.

A2138 CORROSION RESISTANT COATINGS FOR MAGNESIUM TRANSMISSION GEARBOXES FOR SH60.

Magnesium alloys are widely used on aircraft components due to its light weight and manufacturability. One example of its use is the transmission gearbox on an SH-60 Helicopter as shown Figure 3. Although magnesium and its alloys have many attractive properties, they also have very poor corrosion resistance. In the case of the gearbox, significant corrosion occurs around the bolt holes and recessed areas requiring removal and repair or replacement of the gearbox as shown in Figure 4. Conventional corrosion reduction methods employed on the gearbox involve hazardous coating processes and have limited effectiveness.

The primary objective of this project is to implement a coating system that can be applied to the ZE-41 magnesium alloy in the SH-60 transmission housing. An effective coating system will provide a corrosion resistant layer that will greatly extend the service life of the housings and will also allow for the repair of housings that are removed from service due to extensive corrosion. The coating technique will also be extended to the flight control bridge where both corrosion and

fretting wear are a problem.

The selected coating process must not adversely affect the base material. Magnesium alloys, such as ZE 41, are very susceptible to damage from excess heat and magnesium alloys readily react with molten material deposited by conventional thermal spray methods. It has been demonstrated that HVPC can apply corrosion and wear resistant coatings to steel and aluminum substrates with minimal effect on the substrate and presumably could be effectively utilized on magnesium alloy substrates. It is anticipated that the successful application of an HVPC coating to critical gearbox areas will achieve multiple goals:

- Repair and recovery of damaged transmission housings
- Extended life for transmission housings
- Improved readiness
- Reduction of use of hazardous coating processes
- Decreased work load by reducing mean time between repairs

The goals specific to this project involve the use of HVPC to produce a corrosion resistant coating on a magnesium alloy substrate (ZE41). The coating will be optimized for corrosion resistance and adhesion to the substrate with the requirement that the coating must not adversely affect the mechanical properties of the substrate. Additional work will include application of a coating to non-uniform substrate with recesses and dents to simulate repair of a severely pitted surface.

Candidate coating materials have been identified and include commercially pure aluminum, 4047 Al containing 12% Si for wear resistance, and 5356 Al containing 5% Mg which has good compatibility with magnesium alloys. In similar work, aluminum coatings have been successfully applied to aluminum substrates with good adhesion characteristics. Micrographs of the coating/substrate interface are consistent with a well adherent coating and show no significant porosity as shown in Figure 5. The coatings have demonstrated acceptable adhesion with bond strengths exceeding 48MPa (7000 psi).

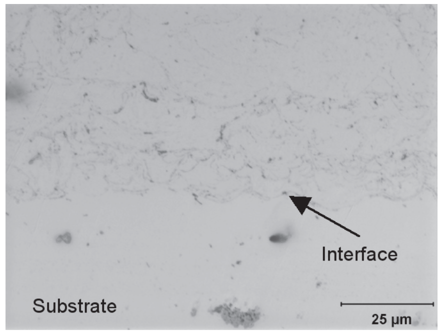

Figure 5. Micrograph of 7090 Al on aluminum 7075-T6 substrate, 1000X

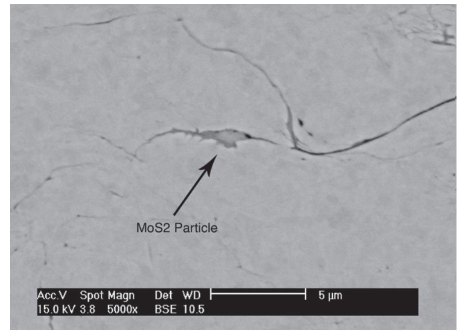

Figure 6. The results of energy dispersive x-ray spectroscopy, which verify the presence of MoS2 in the coating[12].

In the present project, initial screening of the coatings is underway utilizing a fractional factorial Design of Experiments (DOE) matrix to rapidly evaluate multiple process variables including pressure, temperature, stand-off distance, nozzle travel rate, powder feed rate, powder size, and substrate preparation method. The resulting coatings will be evaluated for corrosion resistance and bond strength. The most critical process variables identified in the screening will then be used to optimize the coatings characteristic. Evaluation of the optimized coatings will include tensile, fatigue, bend, bond strength, and corrosion testing.

After the identification and confirmation of optimum coating processing conditions, technology transition of the HVPC process will occur with the installation of a coating system at NADEP – Cherry Point. The transition will include a demonstration on an SH-60 gearbox and training of appropriate personnel. Implementation of the HVPC process will involve multiple aircraft programs including H-60, H-53, H-46.

The ManTech program is leveraged with an Environmental Security Technology Certification Program Supersonic (ESTCP) titled Particle Deposition Technology for Repair of Magnesium Aircraft Components. Through the Navy Mantech and the ESPCP programs, a Joint Test Protocol has been established with the OEMs and representatives from the Navy and Army. Funding will be provided through the ESTCP program to install and qualify a HVPC system at NADEP-CP.

NEW DEVELOPMENTS

Self-Lubricating Coatings

The Materials Processing Division has been working with researchers in Engineering Science and Mechanics Department at The Pennsylvania State University and at Wright Patterson Air Force Base to develop self lubricating coatings for high temperature applications. These coatings are being developed to reduce fretting wear between titanium alloy components in jet aircraft engines. The composite coatings had nickel as the matrix and either Molybdenum-disufide (MoS_2) or Boron Nitride (BN) as the solid lubricant[12]. Process parameters were established for depositing the selected wear resistant coatings. The coatings were characterized for microstructure, bond strength, wear and distribution of lubricant. A typical microstructure showing a solid lubricant particle in the nickel matrix is shown in Figure 6. The Ni-BN composite coatings possess better

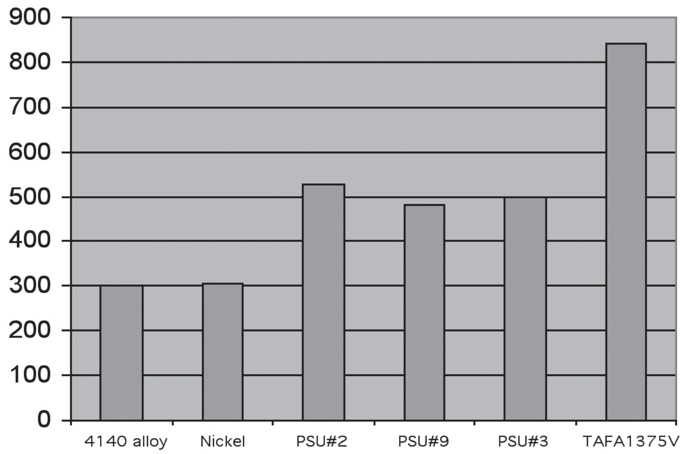

Figure 7. Average Vicker's Hardness Number (VHN0.300) for uncoated and coated nickel, agglomerated and sintered: TAFA 1375(Cr3C2-NiCr)), and blended (Cr3C2-Ni: PSU blend #2, PSU blend #9, PSU blend #2, and TAFA 1375V) coatings applied by HVPC process.

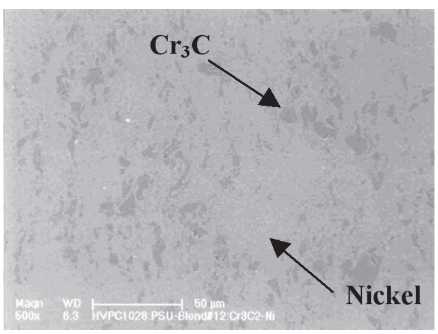

Figure 8. PSU blend #1: Cr3C2-25wt%Ni

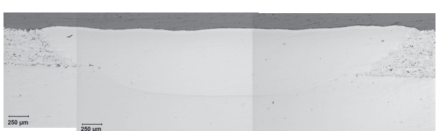

Figure 9. Optical micrograph of laser glazed surface of PSU blend # 2: Cr3C2-25wt.%Ni, showing little porosity due to the increased density of the HVPC coating and dissolution with the substrate due to the increased energy.

comparable hardness and adhesive strength relative to pure Ni coatings. Results indicated a reduction of friction coefficients with the addition of solid lubricants. Efforts to develop coatings that have higher amounts of lubricants are ongoing.

Wear Resistant Coatings recent efforts have focused on developing process parameters required to apply Cr3C2-25wt.%NiCr and Cr3C2-25wt.%Ni coatings on 4140 steel alloy for wear-resistant applications[13]. Improvements were made in the coating properties and microstructure through changes in nozzle design, powder characteristics, stand-off distance, powder feed rate, and traverse speed which resulted in an improved average Vickers hardness number comparable to some thermal spray processes as shown in Figure 7.

Process optimization of the Cr3C2-based coatings resulted in increased hardness and improved wear characteristics. The improvement in hardness is directly associated with higher particle velocities and increased densities of the Cr3C2-based coatings deposited on 4140 steel alloy at ambient temperature. Selective coatings were evaluated using x-ray diffraction for phase analysis, optical microscopy (OM) and scanning electron microscopy (SEM) for microstructural evaluation, and ball-on-disc tribology experiments for friction coefficient and wear determination. A typical microstructure is shown in Figure 8. The results show that HVPC is a versatile coating technique capable of tailoring the hardness of Cr3C2-based wear-resistant coatings on temperature sensitive substrates.

Development efforts have extended to using post processing techniques to modify the coating properties. Laser glazing was investigated as a way of increasing the coating hardness and bond strength. The microstructure of the modified HVPC coating is shown in Figure 9.

Laser glazing can increase the hardness of coatings applied using the HVPC process. The depth of penetration can be controlled by adjusting the laser power and glazing speed. Microwave sintering is also being investigated as a method to modify the HVPC coatings[14].

Effects of HVPC Coatings Mechanical Properties

Work is on-going to better understand how the application of coatings using the HVPC process affects the mechanical properties of the substrate materials. In this study, two different cold spary processes were used to apply a thin layer of Commercially Pure (CP) Al on thin plates of Al7075-T6[15]. Nitrogen and helium were useds as the carrier gas to deposit the CP Al powders. Characterization of the coatings included microstructural analysis, hardness measurements, and tensile, S-N fatigue and bend tests. The tensile and fatigue properties of the substrates were measured in the as-sprayed conditions and after heat treating to an overaged condition. Although there were not enough samples to produce statistically valid results, trends indicated that there is a relationship between mechanical properties of the coated substrate and the depostion velocity of the powders. Additional testing is underway to better understand this relationship.

Other Materials

Research continues on the deposition of composite materials that have very high thermal conductivity for thermal management and direct write applications. Direct write applications include circuits and patch antennas. Development efforts are being extended to nonmetallic powders.

REFERENCES

1. A.P. Alknimov, et.al.,"A Method of Cold Gas Dynamic Deposition", Dokl, Acad. Nauk SSSR, 813, pp. 1062-1065, 1990.
2. A.P. Alknimov, et.al.,"Cold Gas Dynamic Deposition Method for Applying a Coating", US Patent 5,302,421, April 12, 1994.
3. http://www.gordonengland.co.uk/coldspray.htm
4. T. Stoltenhoff, H. Kreye, H. J. Richter, An Analysis of the Cold Spray Process and its Coatings, Journal of Thermal Spray Technology, 11 (4), 2002, pp.542-50.
5. V. F. Kosarev, S. V. Klinkov, A. P. Alkhimov, A. N. Papyrin, On some aspects of gas dynamics of the cold spray process, Journal of Thermal Spray Technology, 12 (2), 2003, pp.265-81.
6. D. L. Gilmore, R. C. Dykhuizen, R. A. Neiser, T. J. Roemer, M. F. Smith, Particle velocity and deposition efficiency in the cold spray process, Journal of Thermal Spray Technology, 8 (4), 1999, pp.576-82.
7. Personal Communication, Army Research Laboratory
8. M. Grujicic, C. Tong, W. S. DeRosset, D. Helfritch, Flow analysis and nozzle-shape optimization for the cold-gas dynamic-spray process, Proceedings of the Institution of Mechanical Engineers, Part B:Journal of Engineering Manufacture, 217 (11), 2003, pp.1603-13.
9. D. L. Gilmore, R. C. Dykhuizen, R. A. Neiser, T. J. Roemer, M. F. Smith, Particle velocity and deposition efficiency in the cold spray process, Journal of Thermal Spray Technology, 8 (4), 1999, pp.576-82.
10. T. J. Eden, J. D. Hoggard, and J.K. Potter, "HVPC Cost Estimator", PSU Invention Disclosure Number 2003-S078, July 24, 2003
11. T.J. Eden, and Potter, J.K."AVV Enhanced Appliqué Armor Kit Product Improvement,", Navy ManTech Final Report, Oct, 2005
12. P. Walia, "Development of Ni-Based Self-Lubricating Composite Coatings for Ti-6Al-4V Dovetail Joints using the Cold Spray Process", Masters Thesis, The Pennsylvania State University, University Park, PA, Aug 2007
13. Wolfe,D.E, et.al. "Investigation and Characterization of Cr3C2-based Wear-Resistant Coatings Applied by the Cold Spray Process", Journal of Thermal Spray, Sep 2006, Vol 15
14. B. W. Shoffner, "Investigation of Microwave Sintering on High Velocity Particle Consolidation Coatings", Undergraduate Honors Thesis, The Pennsylvania State University, University Park, PA, May 2006
15. J.E. Barnes, et.al., "Mechanical and Microstructural Effects of Cold Spray Aluminum on Al 7075 using Kinetic Metallization and Cold Spray Processes", submitted to the Journal of Thermal Spray Technology

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from the approved Navy vendor for comparison evaluation. Following development of test hardware and evaluation techniques, new and repaired gears were tested under loaded conditions to failure. Strength and durability characteristics were evaluated on both the new and repaired gears. This evaluation included Single Tooth Bending Fatigue (STF), Contact Fatigue (CF), and Scoring Resistance (SR) tests on resident ARL Penn State equipment. Results of ARL Penn State's Drivetrain Technology Center evaluation demonstrated that the repaired gears performed as well as new gears. In many instances the performance of the repaired gears was slightly better. This phenomenon is attributed to the improved surface finish, which is an additional by-product of the ISF process.

Project results clearly demonstrate that the repair and reuse of surface damaged gears is a viable option for the Navy. Application of this process has the potential to provide a significant cost avoidance. This gear repair procedure has application towards all fixed-wing and vertical lift aircraft within the military, resulting in further across-the-board operations and service (O&S) savings. Implementation of this repair procedure is being focused at FRC East Cherry Point, with support from NAVAIR and The Boeing Company (manufacturer of the CH-46). For more information on this program effort, contact Suren Rao, Ph.D. at (814) 865-3537 or by e-mail at <sbr1@psu.edu>.

INSTITUTE NOTES

DMC 2006 Concludes

Members of iMAST recently participated in the annual Defense Manufacturing Conference, held in Nashville, Tennessee. Once again, leaders from government, industry, and academia assembled to exchange perspectives and information relative to manufacturing technology, industrial modernization, and related DoD transformational initiatives. This year's theme " Superiority...Affordability…Can We Really Have Both?" set the stage for forum discussions concerning the defense industrial base and its impact on U.S. warfighters, who are currently engaged in full-scale combat in Southwest Asia. The conference featured senior guest speakers from the Department of Defense and industry, as well as various flag officers from the military services. Next year's annual conference will be held in Las Vegas, Nevada from 3-6 December.

CALENDAR OF EVENTS

2007			
9–11 Jan.	Surface Navy Association Symposium	★★★★★★★ *visit the iMAST booth*	Crystal City, VA
30–31 Jan.	ShipTech 2007	★★★★★★★ *visit the iMAST booth*	Biloxi, MS
3–5 April	Navy League Sea-Air-Space Expo	★★★★★★★ *visit the iMAST booth*	Washington, D.C.
6–19 April	Aging Aircraft Conference		Palm Springs, CA
10–12 April	SME Composites Manufacturing		Salt Lake City, UT
1–3 May	American Helicopter Society Forum 63	★★★★★★★ *visit the iMAST booth*	Virginia Beach, VA
7–9 May	Navy (SBIR) Opportunity Forum		Crystal City, VA
30 – 31 May	Letterkenny Depot Business Showcase	★★★★★★★ *visit the iMAST booth*	Chambersburg, PA
31 May – 1 June	Johnstown Showcase for Commerce	★★★★★★★ *visit the iMAST booth*	Johnstown, PA
30 July – 2 Aug	ONR Naval Industry Partnership Conference	★★★★★★★ *visit the iMAST booth*	Washington, D.C.
20–24 Aug	Penn State Rotary Wing Technology Short Course		University Park, PA
TBA Aug	Armstrong County Showcase for Commerce	★★★★★★★ *visit the iMAST booth*	Kittanning, PA
TBA Oct	Expeditionary Warfare Conference		Panama City, FL
2–4 Oct	Marine Corps League Modern Day Marine Expo	★★★★★★★ *visit the iMAST booth*	Quantico, VA
29 Oct – 1 Nov	U.S. Coast Guard Innovation Conference		New Orleans, LA
13–16 Nov	DoD Maintenance Conference		Orlando, FL
3–6 Dec	Defense Manufacturing Conference	★★★★★★★ *visit the iMAST booth*	Las Vegas, NV

Quotable

"We are short of money. Therefore, we must start to think."
— British Physicist Lord Rutherford

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